CAVITY FREQUENCY METER

Model 208A Ser #70

5490 - 8100 Mc

OPERATING INSTRUCTIONS &
TECHNICAL DATA

PUBLICATION NO. 23-1801C
OCTOBER 1951

SPERRY

MICROLINE[1]

CAVITY FREQUENCY METERS

Models

291A 28B, 208A & 273

2575 - 3780 Mc

4010 - 11,900 Mc

The Cavity Frequency Meters in this group are primarily intended for applications requiring a high degree of accuracy and resolution. They are constructed to provide trouble-free operation under all conditions of normal use, and under extremes of temperature and humidity. Their ranges overlap sufficiently to provide continuous frequency coverage from 2575 to 3780 and from 4010 to 11,900 megacycles per second (mc).

APPLICATIONS

These Cavity Frequency Meters are precision instruments designed for laboratory and production test measurements where great accuracy is desired. Resonance indications of either the transmission or absorption (reactive) type can be obtained with these frequency meters.

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Throughout its frequency range each model in the group has an absolute accuracy greater than one part in 10,000 and a loaded Q of 5,000 to 10,000.

FUNCTIONAL DESCRIPTION

The resonant cavity of these instruments is fabricated by a precision process that assures minute tolerances, stress-free metal, and a true cylindrical-shape cavity.

The cavity is tuned by means of a plunger with two folded half-wave traps which provide an excellent short circuit over the operating frequency range of each instrument. This design eliminates the use of contact fingers or sliding contacts which may become unreliable with use. The tuning plunger is actuated by a lead screw drive. The position of the plunger is accurately indicated by a special micrometer scale.

In Models 28B, 208A and 273 the frequency-meter cavity is rigidly joined to the broad surface at the midpoint of a short length of rectangular waveguide of the appropriate size for insertion as part of a transmission line. Input signals may be introduced at either end of the guide, and a fraction of the microwave power is fed into the resonant

cavity through a centrally-located coupling iris in the common wall at the junction surface. The Model 291A input connection is a type-N receptacle.

In order to provide a transmission resonance indication, all models are provided with an output arm which couples a portion of the r-f energy from the cavity through a 1N21B or 1N23B crystal rectifier. The center conductor of the removable output connector is fitted with a crystal retainer and a disk-type by-pass capacitor which prevents r-f leakage into the d-c line. The connector is terminated with a UHF receptacle.

Each instrument is furnished with the specified crystal rectifier, and is calibrated at the factory with this unit installed. It is recommended that this crystal remain in place in the meter at all times.

OPERATION

Since these instruments are designed to provide precision frequency measurements, certain precautions should be observed in their operation. As mentioned previously, all of the cavities except that of Model 291A are mounted on short lengths of waveguide and loosely coupled electrically. This permits direct connection to a transmission line with little

or no effect on the line except when resonance is approached. In all cases, however, it is advisable to keep the transmission line well matched, and to isolate the Frequency Meter from the r-f source by means of a 15- or 20-db matched attenuator pad. The Model 291A may be connected to a transmission line by means of a directional coupler or suitable adapters and a 50-ohm cable.

Both reactive and transmission resonance indications may be obtained with these Frequency Meters in the following manner:

1. To obtain a reactive indication some means must be provided for monitoring the r-f power in the main line. A crystal detecting section, bolometer mount or mixer terminating the line as an r-f head may be used for this purpose. Resonance will be indicated by a pronounced dip in the r-f power level.

2. If a transmission indication is desired, a d-c milliammeter having an input impedance of approximately 250 ohms should be connected to the output arm of the cavity. In order to maintain maximum sensitivity over the full range of crystal current, it is recommended that a 250-ohm tee-pad

attenuator be connected between the crystal and the milliammeter in place of meter shunts. Resonance is indicated by a peak reading of the crystal-current meter.

Because of the high Q of these instruments, it is often convenient to first locate an unknown frequency by the use of a low-Q, search-type frequency meter. After the frequency has been determined approximately, the Cavity Frequency Meter can be used to make a precision measurement. Tune the cavity slowly until a maximum resonance indication is obtained.

OPERATING PRECAUTIONS

1. With modulated signals it is possible to obtain responses at the sideband frequencies. Care must be taken that these resonances are not confused with that of the main signal.

2. When square-wave modulation is used, two responses may be obtained which correspond to two modes of operation of the signal source. The response at the undesired frequency can normally be eliminated by oscillator voltage adjustments to prevent the occurence of the second mode.

Each instrument is furnished with complete calibration data appended to these Operating Instructions. These data include a standard calibration table, universal temperature-correction chart, frequency-correction curve for the individual instrument and a humidity-temperature resonator

correction nomograph. The computations required to obtain desired frequencies or corresponding dial settings are described in subsections A and B below:

A. Determination of The Frequency Corresponding to an Observed Dial Setting.

1. Observe dial setting (D) at Frequency Meter resonance.

2. Ambient Temperature Correction - Correction to (D) the observed micrometer dial setting (in ten-thousandths of an inch) is obtained from the applicable Universal Temperature Correction Chart in which correction (K) is plotted as a function of ambient temperature for various values of D. For values of D not plotted on the chart, the value of K may be obtained by interpolating either arithmetically or visually, making some allowance for the fact that K is not linear in D, but cubic. The value of K is then added algebraically to the initial dial reading to obtain the corrected dial reading R':

$$R' = D + K$$

3. Correction for Deviation from Standard Calibration- A second correction to the dial setting is applied by reference to the Correction Curve for the particular instrument. The dial reading (R) lies along the X axis. The correction (d)

to be made to R' is obtained by reading the value found on the Y axis at the intersection of the curve and R'. Adding algebraically, the corrected dial reading (R) is then:

$$R = R' + d$$

4. Interpolation - If the value for R found in step 3 does not appear in Column 1 of the Standard Calibration Table, the interpolated frequency (f_{int}) may be obtained from the table by two computations. Column 1 of the table gives the dial setting in increments which correspond to linear variations of frequency. Column 2 gives the frequency corresponding to the values of dial setting in Column 1. Column 3 gives the tabular frequency difference (ΔF) between two successive values in Column 2. The computations are made as follows:

a. $$\Delta f = \frac{\Delta F}{\Delta D} (D_G - R)$$

where Δf = interpolation frequency increment

ΔF = frequency difference (Col. 3) between the tabulated values (Col. 2) corresponding to the nearest pair of tabulated dial settings (Col. 1) above and below the observed (corrected) reading (R)

ΔD = difference between the nearest pair of tabulated dial settings (Col. 1) above and below (R)

R = observed dial setting corrected for ambient temperature and individual meter deviation

D_G = nearest tabulated dial setting (Col. 1) greater than (R)

b. Then

f_{int} = Δf + (Tabular Frequency (Col. 2) corresponding to D_G)

5. Humidity Correction - Application of the humidity correction (Δf_1) is the last step. Record ambient relative humidity and temperature, and refer to the Universal Nomograph. The interpolated frequency is corrected for the value of Δf_1 obtained from the nomograph by substitution in the following equation:

$$f_o = f_{int}\left(1 - \frac{\Delta f_1}{100}\right)$$

where

$\Delta f_1/100 = \Delta f_1\%$ = value taken from nomograph (retain sign)

f_{int} = interpolated frequency (step 4)

to give the final corrected frequency (f_o) corresponding to the original observed Cavity Frequency Meter dial setting.

B. Determination of Dial Reading Corresponding to a Given Frequency

The steps outlined in A. for the accurate determination of a desired frequency are reversed as shown below when the dial setting for a given frequency (f_c) is required.

1. Relative Humidity Consideration - The value of Δf_1% for ambient relative humidity is taken from the nomograph and:

$$f_{int} = \frac{f_c}{1 + (\Delta f_1 - 100)}$$

where the notation is the same as in Part A of the "OPERATION" section above.

2. Interpolation for Tabulated Dial Setting (R) -

a. $$\Delta d = \frac{\Delta D}{\Delta F} (f_{int} - f_L)$$

where Δd = interpolation dial setting increment

ΔD = difference in inches between the nearest pair of tabulated dial setting values (Col. 1) above and below that corresponding to f_{int}

ΔF = frequency difference (Col. 3) between the nearest pair of tabulated frequency values (Col. 2) above and below

f_{int} = tabular frequency obtained from step 1 above

f_L = nearest tabulated frequency less than $f_{...}$

b. Then

R = (Tabulated Dial Setting corresponding to f_L) - Δd

3. Correction for Deviation from Standard Calibration Table and Ambient Temperature -

a. $R' = R - d$

where d is obtained from the individual Correction Curve for the instrument and is subtracted from R algebraically

b. $D = R' - K$

where K is obtained from the applicable Universal Temperature Correction Chart and is subtracted from R' algebraically

This will give D, the actual Frequency Meter dial setting, for any given frequency within the range of the particular instrument.

In order to secure maximum accuracy from these Cavity Frequency Meters, it is necessary to apply all the corrections as indicated. However, close approximations to actual frequency can be obtained by the use of the individual frequency deviation Correction Curve only. In the measurement of frequency differences good accuracy will also result from consideration of the particular deviation Correction Curve alone.

MAINTENANCE

These instruments are designed for minimum servicing. The mechanical construction provides a minimum of sliding surfaces, reducing wear. All Cavity Frequency Meters are fully adjusted and accurately calibrated at the factory and no maintenance should be performed by the customer. If the rectifier crystal becomes damaged, the Frequency Meter should be returned to the manufacturer for replacement, otherwise the calibration may be affected.

SPECIFICATION TABLES

TABLE I

ELECTRICAL CHARACTERISTICS

Model No.	Frequency Range (Mc)	Absolute Accuracy	Loaded Q	Calibration
291A	2575 to 3780	1/10,000	10,000	Table
28B	4010 to 6000	1/10,000	7,000	Table
208A	5490 to 8100	1/10,000	7,000	Table
273	8100 to 11,900	1/10,000	5,000	Table

TABLE II

TRANSMISSION LINE AND CONNECTOR TYPES

Model No.	Rectangular Waveguide AN Type	Size (Inches)	Connectors Input AN Type	Output
291A	-	-	Type-N Jack[1]	UHF Receptacle[2]
28B	RG-49/U	2x1x.064	UG-149A/U	UHF Receptacle[2]
208A	RG-50/U	1-1/2x3/4x.064	UG-344/U	UHF Receptacle[2]
273	RG-52/U	1x1/2x.050	UG-39/U	UHF Receptacle[2]

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[1] Type-N jack similar to UG-32B/U and mates with UG-21B/U or other 50-ohm type-N plug.

[2] UHF Receptacle similar to UG-224/U.

TABLE III

PHYSICAL CHARACTERISTICS

Model No.	Overall Size (Inches) Length	Width	Height	Weight (lb)
291A	8-3/8	8-1/8	12-3/4	17-1/2
28B	6-1/2	5-1/2	9-1/8	7-1/4
208A	6-1/16	5	6-3/4	4-7/8
273	4-5/8	4-1/16	5-3/8	2

FINISHES

All electrical surfaces are given a high-conductivity silverplated finish covered by rhodium which provides excellent protection against corrosion. Non-conducting surfaces are finished in black enamel.

SERVICE AND REPAIRS

Inquiries regarding the servicing, repair or operation of any Microline instrument should be directed to Field Service Engineering Department at the address below. Do not return any unit before making this contact.

SPERRY GYROSCOPE COMPANY
Division of The Sperry Corporation
GREAT NECK, NEW YORK

STANDARD CALIBRATION TABLE*

for

MODEL 208A
MICROLINE CAVITY FREQUENCY METER
SERIAL NO._

5490 - 8100 Mc

1 Dial Setting (Inches)	2 Frequency (Mc)	3 Frequency Difference (Mc)	1 Dial Setting (Inches)	2 Frequency (Mc)	3 Frequency Difference (Mc)
0.19250	8103.0		0.2475	7738.0	
0.19500	8085.1	17.9	0.2500	7722.6	15.4
0.19750	8067.5	17.6	0.2525	7707.4	15.2
			0.2550	7692.3	15.1
0.2000	8050.1	17.4	0.2575	7677.2	15.1
0.2025	8032.8	17.3			
0.2050	8015.6	17.2	0.2600	7662.2	15.0
0.2075	7998.4	17.2	0.2625	7647.3	14.9
0.2100	7981.3	17.1	0.2650	7632.4	14.9
0.2125	7964.3	17.0	0.2675	7617.7	14.7
0.2150	7947.5	16.8	0.2700	7603.1	14.6
0.2175	7930.8	16.7	0.2725	7588.5	14.6
			0.2750	7574.0	14.5
0.2200	7914.2	16.6	0.2775	7559.6	14.4
0.2225	7987.7	16.5			
0.2250	7881.2	16.5	0.2800	7545.2	14.4
0.2275	7864.8	16.4	0.2825	7530.9	14.3
0.2300	7848.5	16.3	0.2850	7516.8	14.1
0.2325	7832.4	16.1	0.2875	7502.9	13.9
0.2350	7816.5	15.9	0.2900	7489.1	13.8
0.2375	7800.6	15.9	0.2925	7475.3	13.8
			0.2950	7461.5	13.8
0.2400	7784.8	15.8	0.2975	7447.8	13.7
0.2425	7769.1	15.7			
0.2450	7753.5	15.6	0.3000	7434.1	13.7
0.2475	7738.0	15.5	0.3025	7420.5	13.6

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*This Calibration Table applies to any Model 208A Frequency Meter above serial number 19, with the exception of number 27. The date corresponds to standard operating conditions of 25° C. and 60% R. H.

Standard Calibration Table — Model 208A Frequency Meter

1 Dial Setting (Inches)	2 Frequency (Mc)	3 Frequency Difference (Mc)	1 Dial Setting (Inches)	2 Frequency (Mc)	3 Frequency Difference (Mc)
0.3025	7420.5		0.3900	6995.0	
0.3050	7407.1	13.4	0.3925	6984.0	11.0
0.3075	7393.8	13.3	0.3950	6973.0	11.0
0.3100	7380.6	13.2	0.3975	6962.1	10.9
0.3125	7367.4	13.2			
0.3150	7354.3	13.1	0.4000	6951.3	10.8
0.3175	7341.3	13.0	0.4025	6940.6	10.7
			0.4050	6930.0	10.6
0.3200	7328.4	12.9	0.4075	6919.4	10.6
0.3225	7315.6	12.8	0.4100	6908.8	10.6
0.3250	7302.8	12.8	0.4125	6898.3	10.5
0.3275	7290.1	12.7	0.4150	6887.8	10.5
0.3300	7277.5	12.6	0.4175	6877.4	10.4
0.3325	7265.0	12.5			
0.3350	7252.5	12.5	0.4200	6867.1	10.3
0.3375	7240.1	12.4	0.4225	6856.8	10.3
			0.4250	6846.6	10.2
0.3400	7227.7	12.4	0.4275	6836.5	10.1
0.3425	7215.4	12.3	0.4300	6826.4	10.1
0.3450	7203.2	12.2	0.4325	6816.3	10.1
0.3475	7191.0	12.2	0.4350	6806.3	10.0
0.3500	7178.9	12.1	0.4375	6796.4	9.9
0.3525	7166.9	12.0			
0.3550	7155.0	11.9	0.4400	6786.5	9.9
0.3575	7143.1	11.9	0.4425	6776.7	9.8
			0.4450	6767.0	9.7
0.3600	7131.3	11.8	0.4475	6757.3	9.7
0.3625	7119.6	11.7	0.4500	6747.6	9.7
0.3650	7107.9	11.7	0.4525	6738.0	9.6
0.3675	7096.3	11.6	0.4550	6728.4	9.6
0.3700	7084.7	11.6	0.4575	6718.9	9.5
0.3725	7073.2	11.5			
0.3750	7061.7	11.5	0.4600	6709.5	9.4
0.3775	7050.3	11.4	0.4625	6700.1	9.4
			0.4650	6690.7	9.4
0.3800	7039.1	11.2	0.4675	6681.4	9.3
0.3825	7028.0	11.1	0.4700	6672.1	9.3
0.3850	7017.0	11.0	0.4725	6662.8	9.3
0.3875	7006.0	11.0	0.4750	6653.6	9.2
0.3900	6995.0	11.0	0.4775	6644.5	9.1

Standard Calibration Table — Model 208A Frequency Meter

1 Dial Setting (Inches)	2 Frequency (Mc)	3 Frequency Difference (Mc)	1 Dial Setting (Inches)	2 Frequency (Mc)	3 Frequency Difference (Mc)
0.4775	6644.5		0.5650	6353.3	
			0.5675	6345.7	7.6
0.4800	6635.4	9.1	0.5700	6338.1	7.6
0.4825	6626.4	9.0	0.5725	6330.6	7.5
0.4850	6617.4	9.0	0.5750	6323.1	7.5
0.4875	6608.5	8.9	0.5775	6315.6	7.5
0.4900	6599.7	8.8			
0.4925	6590.9	8.8	0.5800	6308.2	7.4
0.4950	6582.1	8.8	0.5825	6300.9	7.3
0.4975	6573.3	8.8	0.5850	6293.6	7.3
			0.5875	6286.3	7.3
0.5000	6564.6	8.7	0.5900	6279.1	7.2
0.5025	6555.9	8.7	0.5925	6271.9	7.2
0.5050	6547.3	8.6	0.5950	6264.7	7.2
0.5075	6538.7	8.6	0.5975	6257.5	7.2
0.5100	6530.1	8.6			
0.5125	6521.6	8.5	0.6000	6250.4	7.1
0.5150	6513.2	8.4	0.6025	6243.3	7.1
0.5175	6504.8	8.4	0.6050	6236.2	7.1
			0.6075	6229.2	7.0
0.5200	6496.5	8.3	0.6100	6222.2	7.0
0.5225	6488.2	8.3	0.6125	6215.2	7.0
0.5250	6479.9	8.3	0.6150	6208.3	6.9
0.5275	6471.6	8.3	0.6175	6201.4	6.9
0.5300	6463.4	8.2			
0.5325	6455.3	8.1	0.6200	6194.6	6.8
0.5350	6447.2	8.1	0.6225	6187.8	6.8
0.5375	6439.2	8.0	0.6250	6181.0	6.8
			0.6275	6174.2	6.8
0.5400	6431.2	8.0	0.6300	6167.4	6.8
0.5425	6423.2	8.0	0.6325	6160.7	6.7
0.5450	6415.2	8.0	0.6350	6154.0	6.7
0.5475	6407.3	7.9	0.6375	6147.3	6.7
0.5500	6399.4	7.9	0.6400	6140.6	6.7
0.5525	6391.6	7.8			
0.5550	6383.8	7.8	0.6450	6127.7	12.9
0.5575	6376.1	7.7	0.6500	6114.9	12.8
			0.6550	6102.1	12.8
0.5600	6368.5	7.6			
0.5625	6360.9	7.6	0.6600	6089.4	12.7
0.5650	6353.3	7.6	0.6650	6076.8	12.6

Standard Calibration Table — Model 208A Frequency Meter

1 Dial Setting (Inches)	2 Frequency (Mc)	3 Frequency Difference (Mc)	1 Dial Setting (Inches)	2 Frequency (Mc)	3 Frequency Difference (Mc)
0.6650	6076.8		0.8200	5736.7	
0.6700	6064.3	12.5	0.8250	5727.2	9.5
0.6750	6051.9	12.4	0.8300	5717.8	9.4
			0.8350	5708.4	9.4
0.6800	6039.6	12.3			
0.6850	6027.4	12.2	0.8400	5699.1	9.3
0.6900	6015.3	12.1	0.8450	5689.8	9.3
0.6950	6003.4	11.9	0.8500	5680.6	9.2
			0.8550	5671.5	9.1
0.7000	5991.6	11.8			
0.7050	5979.9	11.7	0.8600	5662.5	9.0
0.7100	5968.3	11.6	0.8650	5653.6	8.9
0.7150	5956.8	11.5	0.8700	5644.8	8.8
			0.8750	5636.1	8.7
0.7200	5945.4	11.4			
0.7250	5934.0	11.4	0.8800	5627.5	8.6
0.7300	5922.7	11.3	0.8850	5619.0	8.5
0.7350	5911.5	11.2	0.8900	5610.5	8.5
			0.8950	5602.0	8.5
0.7400	5900.4	11.1			
0.7450	5889.4	11.0	0.9000	5593.6	8.4
0.7500	5878.6	10.8	0.9050	5585.2	8.4
0.7550	5867.9	10.7	0.9100	5576.9	8.3
			0.9150	5568.7	8.2
0.7600	5857.3	10.6			
0.7650	5848.8	10.5	0.9200	5560.5	8.2
0.7700	5836.4	10.4	0.9250	5552.4	8.1
0.7750	5826.1	10.3	0.9300	5544.4	8.0
			0.9350	5536.5	7.9
0.7800	5815.9	10.2			
0.7850	5805.7	10.2	0.9400	5528.7	7.8
0.7900	5795.5	10.1	0.9450	5521.0	7.7
0.7950	5785.6	10.0	0.9500	5513.3	7.7
			0.9550	5505.7	7.6
0.8000	5775.0	9.9			
0.8050	5765.8	9.9	0.9600	5498.1	7.6
0.8100	5756.0	9.8	0.9650	5490.3	7.8
0.8150	5746.3	9.7			
			0.96535	5490.0	6.3
0.8200	5736.7	9.6			

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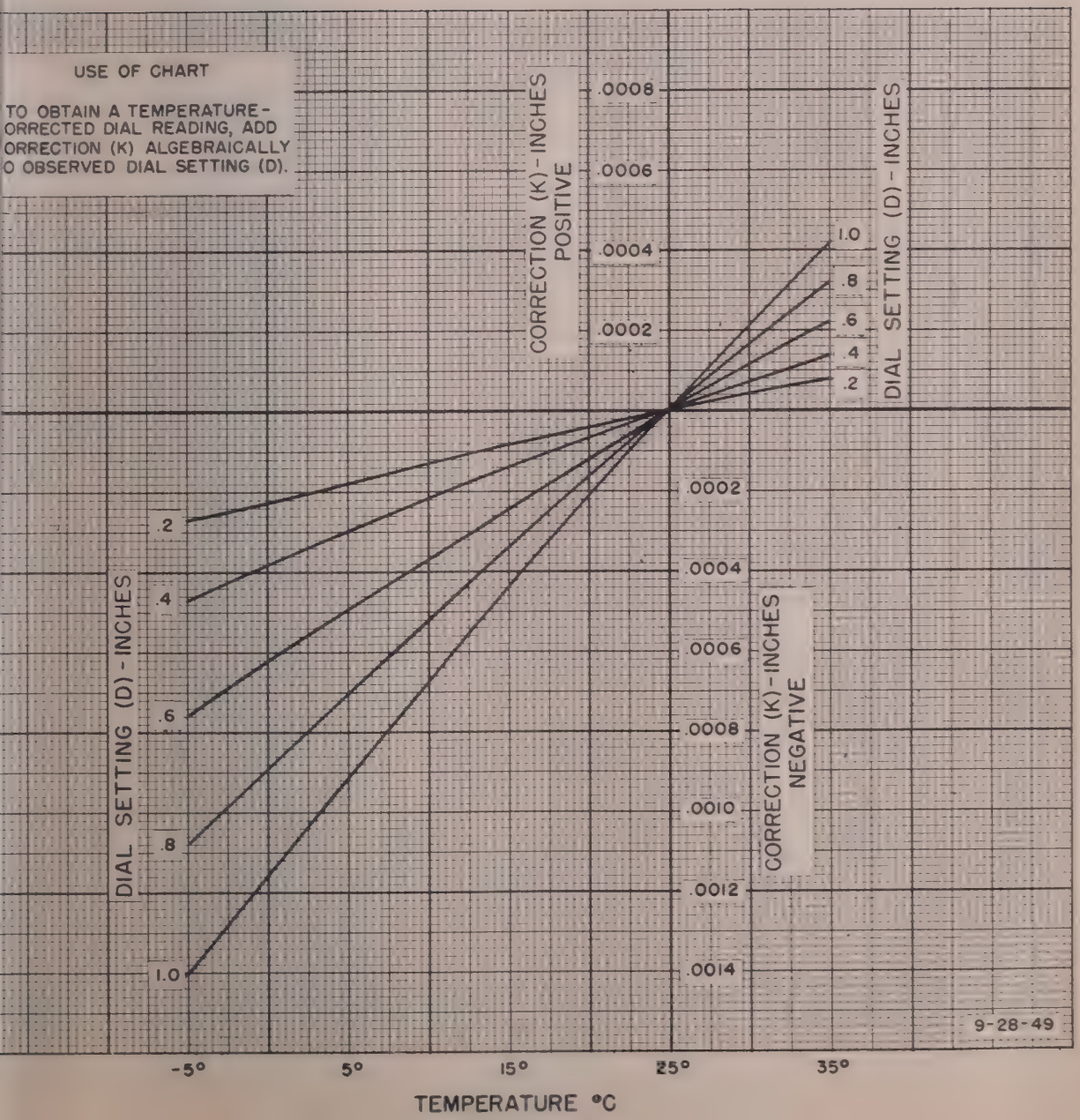
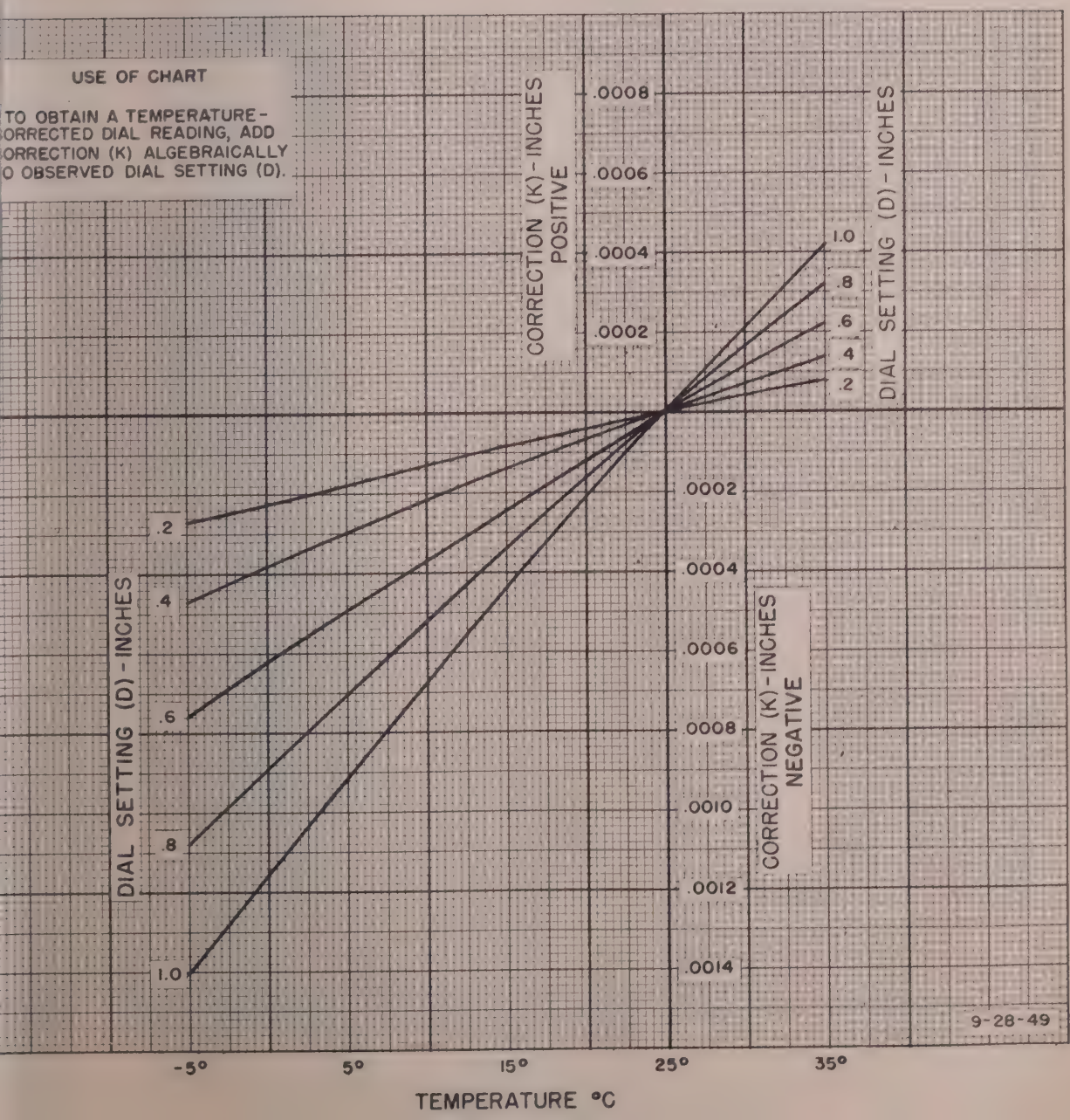
UNIVERSAL TEMPERATURE CORRECTION CHART

MICROLINE
CAVITY FREQUENCY METER
MODEL 208 A



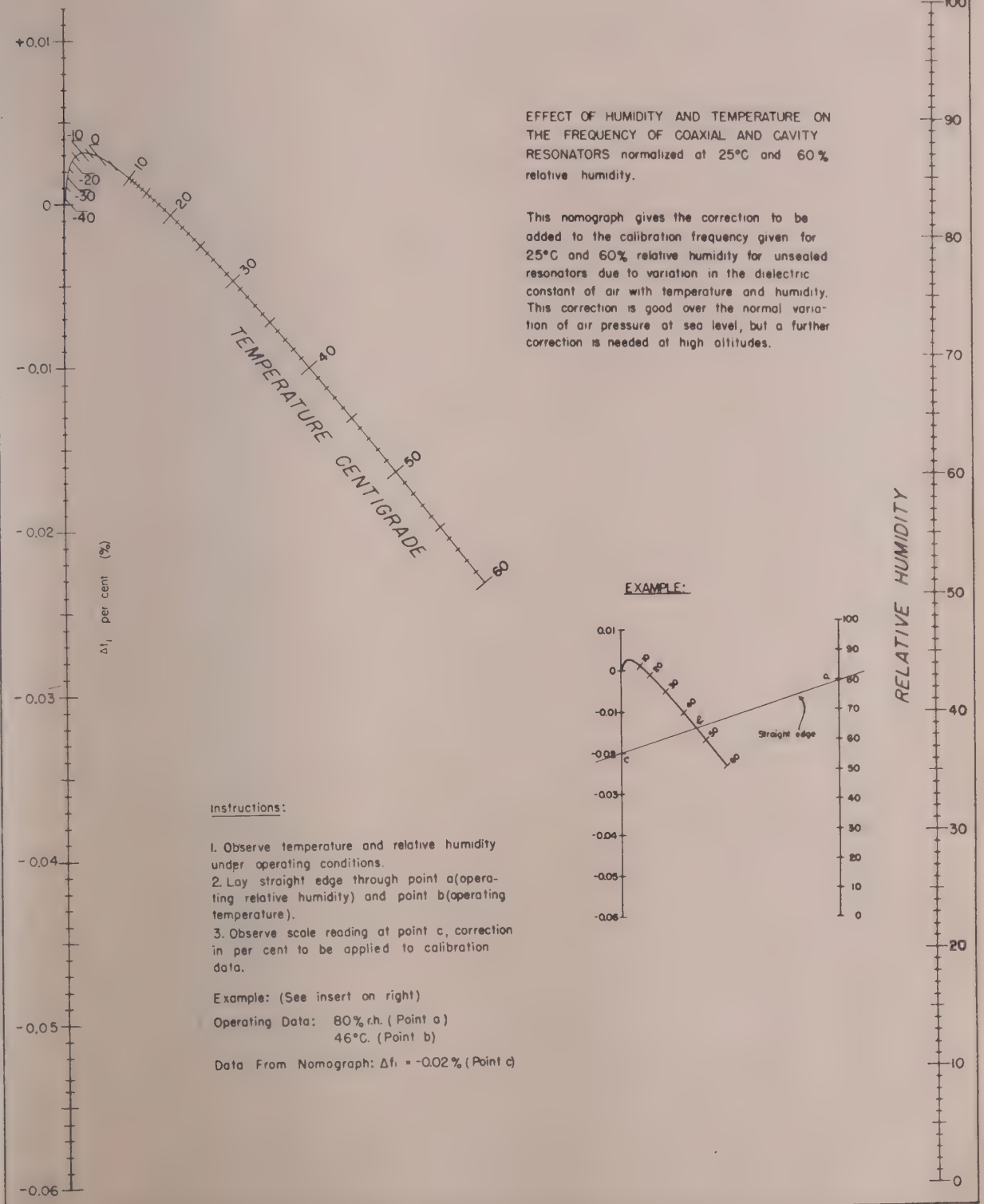
UNIVERSAL TEMPERATURE CORRECTION CHART

MICROLINE
CAVITY FREQUENCY METER
MODEL 208 A



EFFECT OF HUMIDITY AND TEMPERATURE ON THE FREQUENCY OF COAXIAL AND CAVITY RESONATORS normalized at 25°C and 60% relative humidity.

This nomograph gives the correction to be added to the calibration frequency given for 25°C and 60% relative humidity for unsealed resonators due to variation in the dielectric constant of air with temperature and humidity. This correction is good over the normal variation of air pressure at sea level, but a further correction is needed at high altitudes.



EXAMPLE:

Instructions:

1. Observe temperature and relative humidity under operating conditions.
2. Lay straight edge through point a(operating relative humidity) and point b(operating temperature).
3. Observe scale reading at point c, correction in per cent to be applied to calibration data.

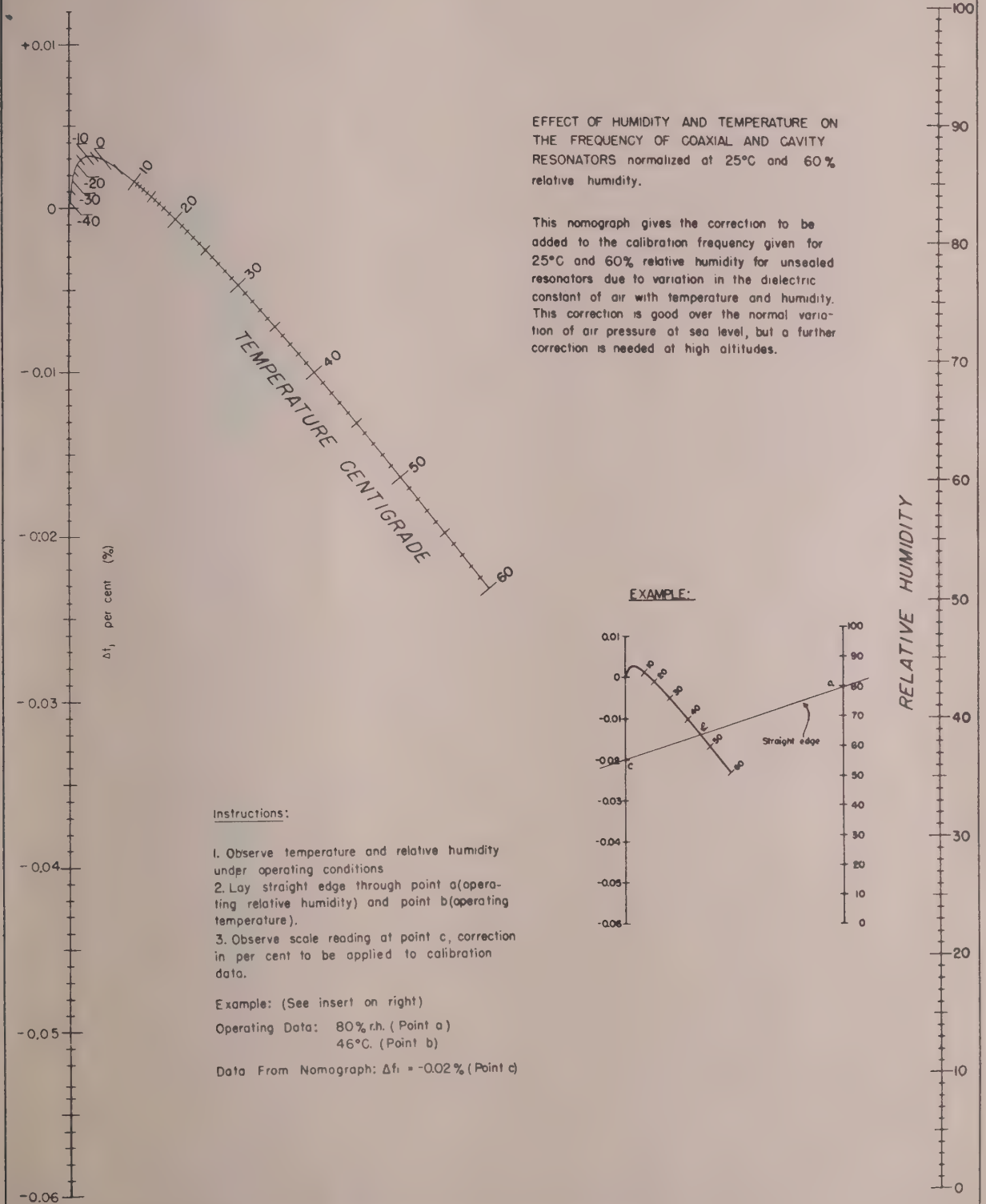
Example: (See insert on right)

Operating Data: 80% r.h. (Point a)
46°C. (Point b)

Data From Nomograph: $\Delta f_i = -0.02\%$ (Point c)

EFFECT OF HUMIDITY AND TEMPERATURE ON THE FREQUENCY OF COAXIAL AND CAVITY RESONATORS normalized at 25°C and 60% relative humidity.

This nomograph gives the correction to be added to the calibration frequency given for 25°C and 60% relative humidity for unsealed resonators due to variation in the dielectric constant of air with temperature and humidity. This correction is good over the normal variation of air pressure at sea level, but a further correction is needed at high altitudes.



EXAMPLE:

Instructions:

1. Observe temperature and relative humidity under operating conditions
2. Lay straight edge through point a(operating relative humidity) and point b(operating temperature).
3. Observe scale reading at point c, correction in per cent to be applied to calibration data.

Example: (See insert on right)

Operating Data: 80% r.h. (Point a)
46°C. (Point b)

Data From Nomograph: $\Delta f_1 = -0.02\%$ (Point c)

TO OBTAIN CORRECTED DIAL READING, ADD CORRECTION ALGEBRAICALLY TO OBSERVED DIAL READING.

SPERRY MICROLINE
CAVITY FREQUENCY METER
MODEL 208A SERIAL NO. 70
5490-8100 MC

CORRECTION CURVE

Drawn by L. Fiedler 2/9/53 Date
Checked by [illegible] 2/9/53 Date
Approved by R. Rinkerd 2/9/53 Date

CORRECTION – INCHES

POSITIVE .003 .002 .001 0 .001 .002 .003 NEGATIVE

.150 .200 .250 .300 .350 .400 .450 .500 .550 .600 .650 .700 .750 .800 .850 .900 .950 1.000

DIAL READING – INCHES

23-1801A-K3

TO OBTAIN CORRECTED DIAL READING, ADD CORRECTION ALGEBRAICALLY TO OBSERVED DIAL READING.

SPERRY MICROLINE
CAVITY FREQUENCY METER
MODEL 208A SERIAL NO. 70
5490-8100 MC

CORRECTION CURVE

Drawn by L. Ferbuth 2/9/53 Date
Checked by [illegible] 2/9/53 Date
Approved by R. Parkins 2/9/53 Date

CORRECTION – INCHES

POSITIVE .003 .002 .001 0 .001 .002 .003 NEGATIVE

.150 .200 .250 .300 .350 .400 .450 .500 .550 .600 .650 .700 .750 .800 .850 .900 .950 1.000

DIAL READING – INCHES

23-1801A-K3